# SURVIVABILITY DATABASE SYSTEM (SUDS)

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## ABSTRACT (U)

(U) This paper presents a proposed survivability analysis system that utilizes existing CASTFOREM data as input for various survivability analyses. The proposed system consists of a translation/extraction routine to reorganize and reformat CASTFOREM output data, a database to store and access this data, and a variety of survivability analysis tools.

(U) This paper presents an approach that utilizes the large data set from CASTFOREM output files to perform survivability analysis on actual and potential engagement data. Potential engagements are defined as those engagements that could occur if conditions (for example, threat sector of regard) were different, but might not be because of user or pre-defined scenario parameters. All actual engagements are a subset of potential engagements. This approach allows a single baseline data set to be used for analyses of many different survivability issues. The results of one analysis can be compared directly with the results of another, thus allowing the relative merits of each system to be evaluated because they are compared using a common data set with the same assumptions and conditions already embedded.

(U) This effort is not intended to change the CASTFOREM simulation in any way or duplicate work that has already been done. The proposed approach utilizes existing data from CASTFOREM in a new way to extract engagement distributions that are inherent in the data set, but are not readily accessible in its pre or post processed form.

(U) Key concepts to be explained include: 1) how to gain access to existing data; 2) how to use the data to create distributions of combat engagements that can be applied to survivability analysis, and 3) an outline of some of the advantages to utilizing data with embedded tactics, terrain, and weather conditions in survivability analyses.

## (U) INTRODUCTION

(U) This paper outlines a proposed project to develop an automated process that translate CASTFOREM output data to PC format, store it in a database where it is readily accessible for combat survivability analyses. This paper presents a plan that involves:

- modifying existing ARL owned translation software
- creating interfaces that access CASTFOREM output data, utilizing TRAC-HEAT as a model for development
- developing a database structure modeled after TRAC-HEAT to output necessary data sets for survivability analysis,
- expanding an already existing toolbox of analysis tools, and
- developing new tools specifically addressing survivability issues.

(U) These tasks are required to create and develop a robust survivability analysis package that utilizes output data from CASTFOREM without re-running the model. Data from previously run scenarios can be used to conduct survivability analyses.

(U) PROBLEM

(U) Since the early 1990's, the Ground Systems survivability community has discussed ways to utilize existing FonF model data for engineering level survivability analyses. Specifically, discussions have revolved around the need for government agencies to collaborate in their efforts to conduct their unique missions, provide each other with necessary data products and support to fulfill these missions, and, as an integrated team, support the Army survivability community. This paper addresses this important goal by leveraging data products from TRAC to conduct SLAD analyses without burdening these organizations with the need for additional specialized data. The resulting products can be returned to the originating organization for use in their analysis efforts, or be used to support decision-making tasks leading to the milestone decisions, all the while supporting survivability analyses requirements.

(U) TRAC's CASTFOREM provides the military community with analytical tools to aid in tactical, operational, and equipment decisions. Typically, CASTFOREM output is available to outside users in post-processed form. The difficulty with the unprocessed or "raw" output from CASTFOREM is the massive volume of data produced that makes it necessary to provide external users with post-processed data. For example, CASTFOREM post-processing provides a "killer-victim (K-V) scoreboard" that offers data from the actual performance of forces under the pre-determined conditions selected by the user. It does not include any information about results that might occur if conditions were different. Typically, the data for different conditions is only available by running the model again. Re-running CASTFOREM can be a time and resource-consuming task.

(U) The CASTFOREM routines that increase the data set, such as the movement routine, can be disabled to keep the output file relatively small. Disabling the movement function makes sense when the analyst is primarily interested in the K-V scoreboard because the data set is small and the results are the same whether the movement function is active or not. However, if the analyst is interested in engagement analyses throughout the battle, the movement routine must be activated to record the engagements, thus making the data set very large. The movement data contain information on the engagement relationships between Blue and Red forces that is critical for survivability analysis. Finding these data is currently a manual, tedious, and time-consuming procedure. This task could be automated to improve efficiency and reduce cost.

(U) This paper presents an approach that utilizes the large data set from unprocessed CASTFOREM output to perform survivability analysis on actual and potential engagement data. Potential engagements are defined as those engagements that could occur if conditions were different, but do not because of pre-defined scenario parameters. All actual engagements are a subset of potential engagements. For example, in a given

CASTFOREM scenario, the conditions of the battle dictate that Blue tanks use a range finder to determine range-to-target, but they are not allowed to fire a munition. Results reported in the K-V scoreboard do not reflect the ranging event as an engagement although it is a consideration for survivability issues. This potential engagement can be and should be used in survivability analysis. These data are not available from the current post-processor results, but are available from the unprocessed output.

(U) Data for potential engagement opportunities can be extracted from existing data using the proposed approach without having to re-run CASTFOREM. This allows a single baseline-data set to be used for analyses of many different survivability issues. The results of one survivability analysis can be compared directly with the results of another, thus allowing the relative merits of each system to be evaluated because they are compared using the same data set.

## (U) SOLUTION

### (U) Approach

(U) A solution to the issues addressed above involves the development of a database system that consists of 1) a translation routine, 2) a database with queries that will generate data in a functional format for analytical studies, and 3) a "toolbox" of survivability related analytical tools. The proposed Survivability Database System (SuDS) concept is illustrated in Figure 1.

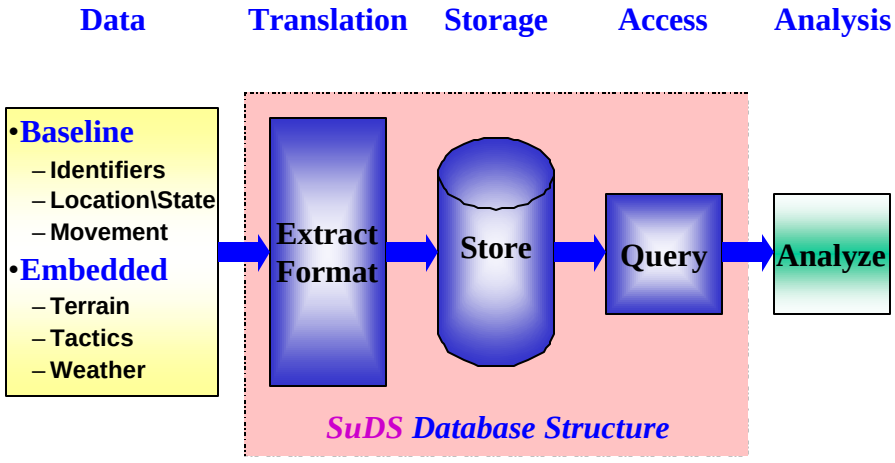


**Figure 1: (U) Survivability Database System (SuDS) Concept Diagram**

(U) Translation Routine

(U) The translation routine will put CASTFOREM in a PC format and provide an automated interface between CASTFOREM and the SuDS database. This task will require a close collaboration with TRAC personnel so that the translation routine reads and interprets existing output structures correctly from the CASTFOREM output data. As CASTFOREM changes, the SuDS translation routine must change, too. This parallel development requires a close and functional relationship between the two organizations.

(U) Database Development

(U) The basic elements to be captured in this database are platform identification, position, and time values. These data will be used to generate various engagement distributions important for survivability analysis. Timelines, positional snapshots of weapon systems through the battle, lines-of-sight, and other important characteristics of battlefield components can all be derived from position and time information.

(U) The structure of this database might begin with two basic tables: a position-and-time table and a weapon system identifier table. The position-and-time table will store x, y, z, (position) and t (time) values for each unit at discrete time steps for the duration of the battle. This table defines movement through the battle. The weapon system identifier table defines the capabilities of the system and will include size, munition type, maximum range, minimum range, and speed. The two tables will be linked by a common identifier such as bumper number or unit identification number. Characteristics of the tactics used, the engagement, and the mission of each system are inherent in the data set because they are incorporated into the CASTFOREM scenario input. Therefore, each survivability analysis run for a single set of data can be compared to every other survivability analysis that uses the same data. Other data specific to the unique survivability system will simply require a new query from the database, rather than a completely new run of CASTFOREM.

(U) Queries will be designed to accommodate the requirements posed by external analysis tools. For instance, if one such tool was a very detailed model of a specific threat, the queried data could be presented to that model as a series of initial conditions, the output of the model would then give results based upon data from CASTFOREM. Another set of queries could give the analyst the relationships of one class of units to another class of units. For example, Red tanks versus Blue personnel carriers. With this information, the analyst can determine requirements for potential survivability measures to counter the threat posed by the Red tanks. Yet another analysis could be run on the same set of data that could be a parametric sensitivity analysis answering the question of how the distribution of engagements would have changed had various probabilities such as detection, hit and\or kill varied.

(U) Analysis Toolbox

(U) With the Army's current emphasis on the use of light forces, the need for data that supports hit avoidance analyses is critical. Much of this data takes the form of position data; that is, range from threat to the platform of interest and angles of regard relative to the platform. For example, if we presume detection and consider only the hit avoidance aspects, this type of data allows analysts to estimate requirements for survivability measures. For instance, one such survivability measure is a notional threat detector that has a given sector of regard. Will this detector, with its given sector of regard, be able to detect all threats in a specific scenario? If it does not, how can its design be changed so that it has a reasonable chance of detecting all threats? It is positional data that allows these questions to be answered. The strength of an analysis toolbox comes when an analyst wishes to consider many such designs each providing an answer to the survivability questions. Each analysis uses the same data; consequently, the results can be compared directly.

(U) The analysis toolbox will contain procedures and tools used to perform specific types of analysis. Two tools currently exist that can be utilized from this toolbox: Hit Avoidance Survivability Assessment Tool (HASAT) and a timeline analysis procedure. HASAT requires input for target and threat positions, threat sensors, weather conditions, and countermeasures. These data are used to calculate the probability of hit at any user-defined time interval in the engagement. The second tool examines engagement timelines that can be used to analzye the effectiveness of survivability measures. Queries that might be developed for the database to feed this procedure include extracting munition types and weapon system ranges. The timelines generated can be used to create munition type distributions for a given CASTFOREM scenario.

(U) Advantages to Approach

(U) A clear advantage to using existing data from military-approved combat models is that the source data have already been through an Army approval phase as inputs to the combat model. Thus, the resulting data is more acceptable to the military community than data gathered from non-approved data sources. Additionally, CASTFOREM provides a readily available data source that requires minimal effort to obtain from TRAC. Generally, this approach provides results that can be utilized in survivability analyses, design trade-off analyses, and test and evaluation efforts. For current Army programs that require solutions to lighten their loads, research in the survivaiblity arena is crucial. The SuDS approach responds to the need for quick turn-around from data acquisition through analysis and evaluation processes. It also allows fast, direct comparisons between survivability elements of interest.

(U) The data to be stored in the SuDS database will enable the analyst to determine various characteristics of the CASTFOREM battle scenario and generate engagement distributions at individual system or unit type levels. For example, a single scenario is represented by several replications (reps), where all reps have the same initial conditions but vary due to random number generation. Ideally, using the proposed SuDS approach will allow rep-to-rep comparisons within a given scenario. For example, if there are 21 reps of a given CASTFOREM scenario (say Case A) required for a K-V scoreboard analysis, the unprocessed data from these reps can be transferred into the SuDS package and utilized for survivability analyses. All 21 reps of Case A can be compared to each other without having to run CASTFOREM again.

(U) The SuDS database will provide a repository for basic platform and bumper number identification, engagement, and location data that might be used in other analyses. Data analyses can be conducted on one-on-one, unit-by-unit, or force-on-force levels because the data is stored in its most basic elements. New tools can be added to the toolbox easily and quickly by creating interfaces with other existing tools and allowing query customization for output in desired formats.

## (U) CONCEPT

(U) This concept involves the extraction and transfer of CASTFOREM output data to a PC-based database that will allow output of various distributions in terms of three-dimensional position (x, y, z) and time (t). There is no intention to change the input or output of CASTFOREM, only to use the engagement opportunities existing within CASTFOREM output data to conduct additional analyses. These engagement opportunities are the building blocks of further analyses and ultimately new inputs for other combat tools and models. Survivability issues can be addressed with this data. For example, a timeline analysis was conducted for an overwatch capability using CASTFOREM history file data[1]. The study culminated in the establishment of a manual procedure that transfers CASTFOREM data to a PC-based spreadsheet for analysis. If this manual process can be automated, it will provide a tremendous asset to the survivability community because of the increased speed and better data it will supply.

### (U) System Concept

(U) CASTFOREM output data will be available in the SuDS database that might reside on a dedicated server platform. Analyst requests for data would come from dedicated client platforms connected to the server via a controlled local area network. Advantages to this configuration include:

- The client software is independent from the database software.

- Each client platform can be different (i.e., UNIX, Linux, or Windows), thus allowing the analyst to use the SuDS from the platform s/he is most familiar with.

- Distributed configuration allows multiple, simultaneous use of the database.

(U) Software concept

(U) Translation software

(U) CASTFOREM output is produced in .cov file format that cannot be used by PCs. Therefore, a translation procedure is a required step in the SuDS process. A translation routine already exists that takes CASTFOREM output and converts it into formats useable in PC-based commercial spreadsheet programs. This routine, the Survivability Engagement Analysis Tool (SEAT) was developed by SLAD in 1998 and documented in ARL-CR-249[3]. SEAT might serve as the starting point of the SuDS translation routine. The SEAT runs on a UNIX system. It reads the CASTFOREM files from TRAC-provided 4 mm tape. Then, the data is translated, sorted, and stored in text and binary files for export to PC-based applications. This translation routine ulitizes "*.cov" files CASTFOREM output history files before they are post-processed by TRAC.

(U) A second alternative is to model a translation routine after the database TRAC-HEAT. This program, developed by TRAC translates UNIX-formatted text data to a PC format. If this alternative is chosen, the developers must create an interface for the specific CASTFOREM file used as input data. Currently TRAC-HEAT will only pull data from the CASTFOREM post-processed Engagement Acquisition file.

(U) Database

(U) The database component of SuDS must have the capability to utilize CASTFOREM output files that provide, at a minimum, location, time, platform orientation, orientation of turrent in relation to the body, movement status, and individual bumper numbers. In addition, information about the weapons and countermeasures that exist on each vehicle will be handy to match up the location data with specific platforms.

(U) One of the most labor-intensive, time-consuming tasks for CASTFOREM analysts is the accumulation and formatting of CASTFOREM post-processed output files. Text files are generated by the CASTFOREM post-processor that present scenario results in tabular form like the Killer-Victim (K-V) Scoreboard. If information is required for statistical analysis on a rep-by-rep basis, then the analyst must post process each replication. The analyst may pull data from 5 to 10 different text files per replication, depending on the information required for the analysis. Multiple alternatives with multiple

replications yield a very large number of output files. As the number of output files increases, the amount of time and the possibility of human error increase. If the desired output is not available in the current post-processing options, the analyst must go to the CASTFOREM modelers/coders to create a customized output file.

(U) TRAC-HEAT was designed to aggregate output data over multiple alternatives and replications. The CASTFOREM output file required for TRAC-HEAT combines all replications, all acquisitions, and all engagement events into one file per scenario. TRAC-HEAT automates the queries that extract the desired information, therefore drastically reducing the opportunities for human error. TRAC-HEAT also allows the analyst to create custom "Measures of Effectiveness (MoE)" queries that bypass the post processor modifications.

(U) TRAC-HEAT uses the Microsoft Access database program running on a Windows NT platform. TRAC-HEAT is written in Visual Basic for Applications (VBA), which provides a method of communication between all Microsoft applications. While intial efforts to develop TRAC-HEAT were done in Microsoft Excel, the relatively small worksheet size prevented the importation and storage of CASTFOREM data. CASTFOREM data can easily record several million events during large scenarios with multiple replications. Microsoft Access has a much larger data storage capacity than Excel. Table size is practically unlimited; however, Windows NT restricts the program to two GB of data.

(U) TRAC identified the need for a tool that would allow multiple alternatives to be analyzed and compared under compressed project schedules. TRAC-HEAT is the result. TRAC-HEAT is now an integral part of the CASTFOREM development process for the Future Combat System (FCS) project. During TRAC-HEAT development and in cooperation with the FCS project, results from over 30,000 replications from more than 1,000 alternatives have been compiled using TRAC-HEAT. Multiply that number by dozens of customized Measures of Effectiveness in addition to the standard engagement and acquisition results collected by TRAC-HEAT, the amount of time and resources saved is staggering. The saved time and resources are then used to decrease the project timeline and improve the quality and depth of analysis.

(U) TRAC-HEAT was developed to provide fast and easy access to data found in the Engagement Acquisition file produced by CASTFOREM's post-processor. It has a sound architecture and meets several of the SuDS requirements: 1) it offers an automated sorting and selection system that reduces the amount of time and potential for human error when conducting analysis; 2) it provides storage, standard and customized query capability; and 3) it exports the results to text, table, and graphic formats to MicroSoft Office

programs. These features make TRAC-HEAT an attractive model to use in SuDS development; however, it does not meet all the minimum requirements.

(U) Specific queries to generate the raw data for a survivability analysis are not currently part of TRAC-HEAT. Queries can be developed relatively quickly in Access, but insuring that they give the right data for an analysis will require some effort. TRAC-HEAT is currently not equipped to take in movement data; however, movement data is available from CASTFOREM. Since many of the envisioned tools will require access to potential engagements, access to movement data is essential.

(U) Applications Toolbox

(U) At this time, there are two SLAD-owned tools that are candidates for the toolbox: The Hit Avoidance Survivability Assessment Tool (HASAT) and a manual procedure to conduct timeline analyses. The HASAT for direct fire engagements is a spreadsheet tool that computes hit probability over time calculated from the time of acquisition to impact or miss. The algorithms used in HASAT take into consideration the combined timelines of a threat and target as they interact in an engagement. The results represent values that consider many unique events that are often ignored in other hit probability modeling efforts. The timeline analysis procedure considers the relative location of threats and targets, their weapons and weapon characteristics, and countermeasures that effect the engagement. Currently, this procedure is a tedious manual task that requires automation. The SuDS database will provide much of the groundwork toward automating this procedure.

## (U) CONCLUSION

(U) Survivability is an important consideration for the transformation to a lighter military force. Tools that can provide information about survivability components, interconnectivity, and integration into military platforms need to be fast and easy to use. The SuDS concept is one solution to these needs. Development of the concept has already begun. Existing models, data, and analysis tools can be utilized in its further development. In todays fiscally constrained environment, cooperation among organizations is essential. Collaboration among organizations is embedded in the SuDS concept and addresses the needs of the Army in transformation.

## (U) ACKNOWLEDGEMENTS

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## (U) GLOSSARY

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| ARL | Army Research Laboratory |
| CASTFOREM | Combined Arms and Support Task Force Effectiveness Model |
| FonF | Force-on-Force |
| HASAT | Hit Avoidance System Analysis Tool |
| K-V | Killer-Victim |
| SEAT | Survivability Engagement Analysis Tool |
| SLAD | Survivability\Lethality Analysis Directorate |
| TRAC | TRADOC Analysis Center |

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